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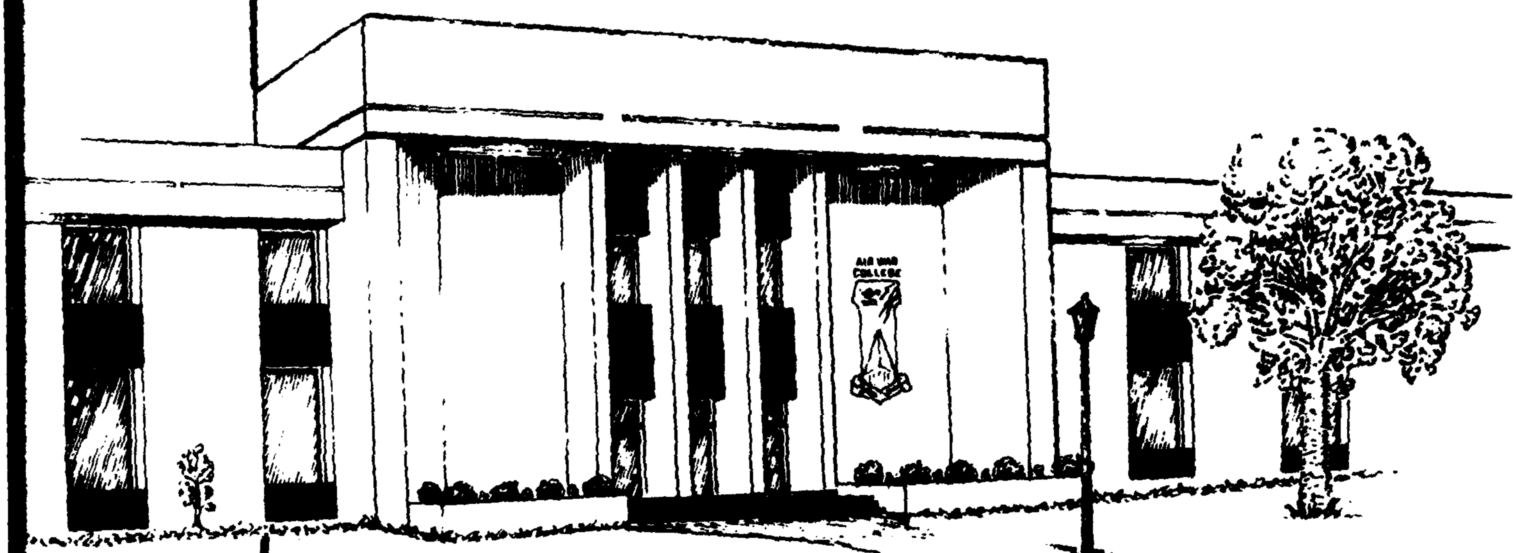
RPV APPLICATIONS IN THE U. S. NAVY

By COMMANDER MAXIMO A. BARELA, USN

AND

COMMANDER JAMES JACKSON, USN



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AIR UNIVERSITY
UNITED STATES AIR FORCE
MAXWELL AIR FORCE BASE, ALABAMA

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RPV APPLICATIONS IN THE U.S. NAVY

by

Maximo A. Barela
Commander, USN

and

James Jackson
Commander, USN

A RESEARCH REPORT SUBMITTED TO THE FACULTY

IN

FULFILLMENT OF THE RESEARCH

REQUIREMENT

Research Advisors: Captain D. Glen Oakes, USN
and
Lt. Col. James H. Smith, USAF

MAXWELL AIR FORCE BASE, ALABAMA

MAY 1988

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AIR WAR COLLEGE RESEARCH REPORT ABSTRACT

TITLE: RPV APPLICATIONS IN THE U.S. NAVY

AUTHORS: Maximo A. Barela, Commander, USN

James Jackson, Commander, USN

This report describes the status of the U.S. Navy's remote piloted vehicle (RPV) program. It also presents numerous possible applications which exploit many of the RPVs' capabilities. The ~~report~~ also questions the aggressiveness and direction of the program and recommends that the program be modified so that it may fully exploit the RPVs' potentials. Appendix I provides data on vehicle and payload capabilities of RPVs which are in current production or which are under development. Appendix II provides a historical military perspective of the RPV from its birth to the present.

BIOGRAPHICAL SKETCHES

Commander Maximo A. Barela joined the Navy after graduating from New Mexico State University with a BS in Electrical Engineering. Since completing flight training, he has served with Patrol Squadron ELEVEN at NAS Brunswick, Maine; Air Test and Evaluation Squadron ONE at Patuxent River, Maryland; Commander Carrier Group FOUR Staff aboard the carriers USS Dwight D. Eisenhower (CVN-69), USS Chester W. Nimitz (CVN-68), and the USS John F. Kennedy (CV-67); Naval Postgraduate School at Monterey, California, where he received a MS in Engineering Systems Technology; and just prior to coming to the Air War College, he was assigned to Patrol Squadron FIFTY-SIX at NAS Jacksonville, Florida. He is a member of the Air War College Class of '88.

Commander James Jackson received a reserve officer commission in the Navy after graduating from Stephen F. Austin University with a BS in Biology and Chemistry. Since completing flight training, he has served with Patrol Squadron NINETEEN at NAS Moffett Field, California; Patrol Squadron THIRTY at NAS Jacksonville, Florida; USS America (CV-66) as Assistant Strike Operations Officer; United States Central Command at Tampa, Florida; and Patrol Squadron FORTY-NINE at NAS Jacksonville. He is a member of the Armed Forces Staff College and of the Air War College Class of '88.

CHAPTER I

INTRODUCTION

The remote piloted vehicle (RPV) is an unmanned, self-propelled aircraft which is capable of being remotely directed, or capable of conducting autonomous operations after being launched. The military potential of these vehicles has increased exponentially in the recent past, and continues to grow due to the many advances in electronics, aircraft composite materials construction, RF energy absorbing coatings, and powerful small engines. These improvements coupled with the amazing results achieved by Israeli Armed Forces using the RPV are responsible for spurring increased interest in the vehicle's military application. Although military applications for the RPV appear to have gained greater acceptance in Israel and many European countries than in the U.S., the U.S. military is in the process of acquiring RPVs and developing operating procedures and tactics on a small scale. This paper will describe the history of the RPV's development from its early beginning to its current applications in the U.S. Navy. It will also provide mission capability data on many of the numerous RPVs which are currently available or which are under development and describe the genesis and current status of the Navy's RPV program. It will describe numerous potential applications for the RPVs chosen for U.S. Navy use and other RPVs which are currently available or are under development. Finally, it will comment on the direction which the U.S. Navy program is taking and other options which should be considered.

CHAPTER II

STATUS OF U.S. NAVY RPV PROGRAM

The reader is encouraged to read Appendix I in order to gain familiarity with the wide variety of RPV capabilities. This familiarity should enable the reader to make an informed assessment of the RPV's utility in military applications. Just from the limited number of RPVs covered in Appendix I, one can see the tremendous amount of capabilities, and potential military applications which these platforms represent. The U.S. Navy's interest in exploiting the RPV's potential is long standing. In fact, the first recorded military application of RPV technology was the Navy's 1915 flight of an unmanned seaplane. (49:4) The major emphasis on RPV military application has been in the remote piloted target area, but there have been some exceptions. The most successful of these exceptions are the RPVs which have been used by the U.S. and Israel in a reconnaissance role. The U.S. used various versions of the Teledyne Ryan Firebee during the Vietnam War and Israel used the Firebee prior to and during their 1973 war with Egypt. More recently, Israel used the Israel Aircraft Industries Scout and the Tadiron Mastiff to conduct real-time reconnaissance which enabled them to counter or outmaneuver the Syrian armed forces during the Israeli 1982 invasion of

Lebanon. The U.S. Navy's renewed interest in expanding RPV applications was spurred by the success achieved by the Israelis. For more historical information on past applications and development of the RPVs, the reader is encouraged to read Appendix II and Brassey's Unmanned Aircraft.

The U.S. Navy, in its attempt to exploit the military potential of the RPVs, has acquired and operationally deployed the Pioneer RPV system aboard the battleship USS Iowa. In addition, the Navy is the lead service for the Department of Defense (DOD) acquisition of a mid-range RPV. The specifications for the mid-range RPV are that the vehicle must be capable of:

- Conducting day/night reconnaissance missions in defended areas while flying at high-subsonic speeds at an operating radius greater than 300 nautical miles
- Acquiring moderate- to high-resolution imagery
- Being reusable and sea recoverable
- Being launched from a ship, aircraft, or from the ground
- Detecting, and identifying targets
- Transmitting data in real- or near real-time in a jamming environment
- Having navigation accuracy which will allow it to fly low-level profiles
- Being preprogrammable for autonomous operations and having the capability of being reprogrammed in flight

It must also have low observables, low operating costs, and the cost per vehicle must be in the $450,000-1,000,000 price range. (24:66-70; 25:24-35; 40:51-56) The Navy, as DOD's lead service for the acquisition of the mid-range

RPV, has selected Northrop's NV-144R and Beech Aircraft's BQM-126A as the two finalists in this competition.

Although the goal of the Department of Defense's program is understandable, in view of fiscal constraints, these goals place grave limitations on the Navy's ability to fully exploit the many capabilities of the RPVs. The ideal RPV would be one which is: affordable; has long legs; has a large payload capacity; has the capability of being launched and recovered from a moving ship in a high sea state with little or no equipment which is not integral to the vehicle; has the capability of being launched from another aircraft; has the capability of conducting preprogrammed autonomous operations; has the capability of being reprogrammed in flight; has the capability of operating in a defended, jamming environment; and has the capability of flying at hover or high-subsonic speeds. Unfortunately, all of these capabilities are not available in any one of the current RPVs, and the cost in time, lost opportunities, and resources which would have to be invested to develop such a vehicle is unacceptable to the Navy. The Navy has chosen to accept the limitations of the current RPVs and acquire the one platform which meets the mid-range RPV specifications, but which does not exploit the full range of RPV capabilities. The option not chosen was that of acquiring various vehicles which are suited to perform the different service-specific missions. This option would in all probability be more expensive when it is compared to the first option. However, the various vehicles of the second option would have greater utility than the one RPV of the first option, and they would probably still be cost effective when compared with the cost of using manned aircraft.

Although the Pioneer, NV-144R, and the BQM-126A appear to be excellent choices, their greatest limitations are their need for ship-board launch/recovery systems which represent costs in system acquisition, ship space, and launch/recovery maintenance space, personnel, and parts. The Pioneer must be recovered via a net. This recovery method, in addition to the costs just mentioned, also represents a high potential for personnel injury and/or vehicle or equipment damage. The NV-144R and BQM-126A are required to land in the ocean, and a ship and/or manned helicopter must be detailed to recover the RPV. Detailing a ship to recover the RPV may place that ship, or the formation in jeopardy. The water landing also increases the potential for RPV/equipment damage due to impact, handling, or water intrusion. A tilt-winged vehicle which meets all of DOD's specifications, although not currently available, would eliminate most of these problems, and be the ideal shipboard RPV. The tilt-winged vehicle would eliminate the need for specialized RPV launch and recovery equipment, and would decrease the probability of personnel and/or equipment damage associated with RPV net and water recoveries.

CHAPTER III

APPLICATIONS

RPVs have the potential to impact every naval mission area. The following examples depict some of the most important mission possibilities.

Antisurface Warfare (ASUW)

RPVs could be used to provide or augment organic air assets and facilitate twenty-four hour, all-weather, 360 degree, over-the-horizon surface surveillance to detect and classify surface contacts, and to target-designate hostile surface targets.

More specifically, one ASUW role for the RPV would be to provide targeting data to data link capable aircraft such as the P-3s or the S-3s. P-3 or S-3 aircraft could carry the RPV(s) to a launch point which is well beyond the weapons' envelope of the hostile platform. The RPV would then fly a programmed flight profile which would enable it to provide continuous targeting and other sensor data to the P-3s/S-3s. The P-3s/S-3s operating under emission control (EMCON), would descend and remain under the hostile platform's sensor horizon while conducting a coordinated Harpoon attack. Another version of this role would have additional RPVs carrying jammers or RF-homing missiles which would neutralize the enemy's antiair/anti-missile hi-emitting sensors prior to the P-3/S-3 Harpoon attack.

The Persian Gulf tanker escort operations provide an excellent opportunity to exploit the potential capabilities of the RPV. Off-the-shelf RPVs and sensors could be operated from strategically located barges or from barges which travel with the convoys. The RPVs would provide low cost, low profile, low signature, all-weather, over-the-horizon sensor and/or offensive capabilities. The greatest benefits would be that these capabilities could be provided free of any host country constraints which could be imposed on land-based aircraft and without the risk of possible damage to high value units such as an aircraft carrier (CV) or helicopter carrier (LPH). Other benefits would be that the operations could be conducted with the reduced probability of loss of an aircraft and its crew, and without the negative press coverage which would be expected to follow the loss of a manned air asset.

Antiair Warfare

RPVs could be used to extend the airborne early warning (AEW) sensor horizon and warning time for a ship or ship formation. In a CVBG environment, the RPVs could be used to supplement the E-2C and facilitate twenty-four hour, 360 degree, all-weather AEW coverage. The RPVs could be stationed beyond the E-2C station(s) along the primary threat vector(s) and in sectors not covered by the E-2C(s).

The RPVs would then transmit their data to the E-2C or Antiair Warfare Coordinator (AAWC). This data would provide a more complete AAW picture and facilitate the battle group commander's weapons selection decision to counter the threat.

A ship or ship formation operating under EMCON conditions could maintain AEW coverage by using RPVs carrying passive sensors such as electronic support measures (ESM), optical sensors, infrared sensors, and/or acoustic sensors, or by using active sensors which are triggered by on-board passive sensors or active sensors which are preprogrammed/in-flight programmable to operate after the RPV has reached a prescribed distance from the ship or formation. The EMCON condition of the ship or formation could also be enhanced by using data link antennas which are highly directional, and systems which use burst transmissions.

RPVs under the control of the E-2C/AAWC could also be used as an offensive antiair multiplier by carrying air-to-air missiles, and for screening inbound aircraft and enforcing return-to-force procedures.

Antisubmarine Warfare (ASW)

RPVs could be used to provide/augment organic airborne assets and facilitate twenty-four hour, all-weather, 360 degree, inner- and/or outer-zone ASW coverage. They could also be used to provide barriers between the threat platform(s) and the friendly unit or to sanitize a route or intended operating area.

The long range RPVs could be used to provide or augment antisubmarine barriers at strategic choke points. These RPVs represent P-3 force multipliers which could continue to operate from dispersed austere or primitive bases even after the P-3 primary bases had been eliminated.

Strike Warfare

The Pioneer's current role of supporting naval gunfire and Tomahawk strike missions is a good start for the RPV. The RPV's strike support missions should be expanded to include support of manned aircraft strike missions. In this role, RPVs could support missions for suppressing enemy antiair weapon systems by providing real-time reconnaissance of surface to air missile and gun positions, by jamming antiair weapon systems' RF emissions, by attacking these same type of systems with RF-homing missiles, by providing real-time reconnaissance for determining target priority and by providing after action damage assessment.

Command and Control

RPVs could be used to provide the battle group commander over-the-horizon ultra high frequency communications coverage for a highly dispersed battle group or among neighboring battle groups even when there is a limited number of satellite channels available. The RPVs could also be used for jamming and deception of enemy radar and communications systems.

Reconnaissance

Many of the applications have already been covered. The important thing to remember when considering the RPV for this role is that it eliminates the risk of losing a high cost manned asset. These RPVs could be used to positively identify a surface target or aircraft before taking it under fire, or for providing pre-mission reconnaissance and post mission damage assessment which is now provided by the very expensive, tactical airborne reconnaissance pod (TARPS) equipped F-14.

Multi-mission Roles

The RPV also has the potential for providing the CVBG commander greater flexibility in determining the carrier air wing composition and carrier deck load. The long range RPVs will also provide the fleet commander greater flexibility for providing his units with land based aircraft support and greater flexibility for basing P-3s for independent, or battle group direct support missions.

RPVs can be used to provide or augment ship or ship formation sensors which extend the ship's or formation's sensor horizon and warning time. These additional sensor capabilities can be a plus to any ship or formation, but they may be especially critical to unarmed or inadequately armed ships which may be required to go in harm's way without a protective umbrella.

Ships from our reserve fleet, or civilian ships like those used by the British during the 1982 Falkland Islands/Islas Malvinas War could be rapidly converted for RPV operations, and could be used as force multipliers to provide convoy or high-value ship protection or to sanitize the route or operating area for carrier battle group (CVBG) or amphibious operations. These RPV carriers (RPV-CVs) would also be ideal for deception missions. Each RPV-CV could simulate a CVBG in every spectrum and force the Soviets to allocate resources to counter the threat. The Soviets could thereby be induced to disperse their forces to counter the "CVBG" threat and make it easier for the U.S. naval commander to defeat the dispersed Soviet elements. In an operating area or route sanitation role, the RPV-CVs would have to be pre-positioned ahead of the CVGB because it is unlikely that the RPV-CVs could keep up with a CVBG. The RPV-CVs could also be used to augment the logistics resources and still perform offensive and defensive missions.

CHAPTER IV

CONCLUSIONS AND RECOMMENDATIONS

The number of U.S. Navy applications for the remote piloted vehicle are limited only by one's imagination, available funding, and the actions of advocates of using manned aircraft exclusively. The applications will certainly not be limited by the ever improving aircraft and sensor technologies. These technologies have produced platforms which are extremely difficult to detect, incorporate highly advanced sensors, and carry secure, jam-resistant communications systems, and are capable of conducting very complex autonomous or operator directed operations. Many of these platforms incorporate most of the latest advances in aircraft composite materials construction and therefore, have a very small radar cross section, and very low infrared, visual, and acoustic signatures. Although the sensors which are currently available or which are in development make the RPVs extremely attractive for a wide range of applications, the Navy program's initial thrust should be directed to mission areas in which manned aircraft are not available for meeting fleet or Marine Corps needs, and to mission areas where the risk of losing an aircraft and its crew far outweighs the desired mission results. However, naval leaders and program directors should attempt to achieve the greatest gain from the limited funds available. Therefore, the Navy's RPV program should also include initiatives for mission areas in which it would be more cost effective to replace manned aircraft with RPVs, and for areas where the RPV can extend the offensive and defensive capabilities of fleet units.

The U.S. is the world leader in RPV development. It has the technological and industrial base to develop and build RPV systems which will help to offset the military gains and advantages which the Soviets now enjoy. The majority of the missions discussed in the applications chapter are within the capabilities of the RPVs and payloads which are currently available or which are in development.

The greatest limitation to the Navy's current RPV program is the restriction which limits the RPV acquisition to one vehicle type for each RPV category.

DOD's RPV program does not allow the acquisition or development of specific types of remote piloted vehicles for specific missions. Future acquisitions should include tilt-wing and rotary-wing remote piloted vehicles which can be launched and recovered from moving ships in extreme weather conditions by using the Recovery, Assist, Secure and Traverse (RAST) System, a device which is used to haul down a helicopter on to a small deck when the ship is operating in rough seas. The RAST System is currently available on many surface combatants, but a mobile, lighter, less expensive RAST type system should be developed for other ships. The combination of the rotary- or tilt-wing RPVs and the RAST recovery would eliminate many of the RPV limitations inherent in the net or in-water recovery systems. This combination would make the RPV a truly all-weather weapons system. In addition, these rotary- or tilt-winged remote piloted vehicles would also provide capabilities which will not be available with the Pioneer, NV-144R, or the BQM-126A. Some of these capabilities are dipping sonar, reusable acoustic jammer, and for deception, a mobile combined acoustic, radar, and communications simulator.

In addition to its NV-144R/BQM-126A acquisition, the Navy, should also procure some rotary- and tilt-winged remote piloted vehicles. These rotary- and tilt-winged RPVs should be used to develop tactics and operating procedures which will facilitate future integration of these types of vehicles into the fleet.

APPENDIX A

RPV DATA

The following data on RPVs, in production or under development, are provided in alphabetical order:

Name of RPV : Altair

Manufacturer: Lockheed Corporation

Cost: Approximately $500,000

Mission: Real-time reconnaissance Sensors: TV or infrared sensors

Range: 250km (137NM)

Maximum speed: 196km/hr (122kts)

Endurance: 11 hours with a 30kg (66 pound) payload

Communications: Narrow-band, burst transmission controller to RPV, and wideband transmission from RPV

Navigation system: Can be preprogrammed and then be reprogrammed in flight

Survivability: Constructed of Kevlar/epoxy composite; its infrared, and radar signature are small

Size: Length - 2.1 meters (6.9 feet); wing span - 3.9 meters (12.8 feet)

Launch: Rail launch

Recovery: Automatic net recovery with a parachute as a backup

(34:63-65)

Name of RPV or project: Amber

Manufacturer or development agency: Defense Advanced Research Agency (DARPA)

Goal: To develop an RPV which has a flight endurance measured in days or weeks.

(24:66-70)

Name of RPV: Aquila

Manufacturer: Lockheed Missiles and Space Company, Inc.

Cost: $800,000 - $1,000,000 per vehicle, 42% of cost is for the payload

Mission: To search, detect, and laser designate targets for U.S. Army precision guided munitions

Sensors: TV or FLIR plus a laser rangefinder-designator and stabilized optics

Range: 50km (27NM)

Ceiling: 12,000 feet

Maximum speed: 200km/hr (120mph); Normal cruise: 49-98mph

Endurance: 3 hours with maximum payload of 60 pounds

Communications: Jam-resistant data link

Navigation system: Inertial with preprogrammed way points and ability to reprogram in flight

Survivability: The Kevlar-49 non-radar reflecting material, vehicle size, and blending of body and wing surfaces create a vehicle with a very small radar cross section, and low infrared and visual signatures

Size: Length - 2.1 meters (6.9 feet); wing span - 3.8 meters (12.5 feet); Total weight - 113kgs (250 pounds)

Launch: Rail launch

Recovery: Automatic, covert net recovery

(6:85-89; 27:74-76)

Name of RPV: Asat

Manufacturer: Flight Refueling Limited

Cost: Unknown

Mission: Search, detection, targeting, decoy and attack

This aircraft is capable of 6G maneuvers.

Sensors: TV, or infrared line scanner

Range: Unknown

Ceiling: Unknown

Maximum speed: 740kts

Endurance: 45 minutes with a payload of 15-50kgs (33-110 pounds)

Communications: Unknown

Navigation system: Unknown

Survivability: Unknown

Size: Length - 3.8 meters (12.5 feet); wing span - 3 meters (9.9 feet); Total weight - 210kgs (462 pounds)

Launch: JATO rocket booster assisted

Recovery: Unknown

(20:64-75)

Name of RPV: Bevel

Manufacturer: MBB and BREVA/Matra

Cost: Unknown

Mission: Day/night and limited all-weather target acquisition and damage assessment

Sensors: High-resolution infrared camera with reversible lens, infrared line-scanner or low-light-level TV

Range: Unknown

Ceiling: Unknown

Maximum speed: Unknown

Endurance: 3 hours with 40kg (88 pound) payload

Communications: Jam-proof data link

Navigation system: Radio-navigation system

Survivability: Unknown

Size: Unknown

Launch: Unknown

Recovery: Unknown

(4:20-26)

Name of RPV: BQM-126A

Manufacturer: Beech Aircraft Corpcration

Cost: Unknown

Mission: Designed as high-speed target

Sensors: Martin Marietta as prime contractor will ensure that the BQM-126A meets the Navy's mid-range RPV program requirements.

Range: Unknown

Ceiling: 40,000 feet

Maximum speed: 670kts

Endurance: 16.6-96 minutes depending on speed; payload - 45.5kg (100 pounds) internal, or 91kg (200 pounds) external

Communications: Not yet defined

Navigation system: Can be preprogrammed or controlled by the ground station

Survivability: Unknown; this vehicle was designed for testing, evaluating, and assessing antiair weapons systems.

Size: Length - 5.52 meters (18.1 feet); wing span - 3.05 meters (10 feet)

Launch: Rocket booster assisted take-off, or air launched

Recovery: Parachute recovery

(61:176)

Name of RPV: Brave 200

Manufacturer: Boeing Military Airplane Company

Cost: Unknown

Mission: Suppression/destruction of radar-guided air defense systems, reconnaissance, target acquisition, jamming, electronic counter measures, and air attack

Sensors: Radio frequency detection and guidance, plus infrared, and optical

Range: Dependent on fuel/payload combination

Ceiling: 3,500 meters (11,500 feet)

Maximum speed: Unknown; cruise - 121kts, loiter - 78kts

Endurance: The endurance will depend on the fuel/payload combination, the maximum payload/fuel capacity is 50kgs (120 pounds).

Communications: Unknown

Navigation system: Preprogrammed flight plan

Survivability: Designed to be expendable

Size: Length - 2.1 meters (6.9 feet); wing span - 2.6 meters (8.5 feet) with wings that fold along the fuselage. Total weight 120kgs (264 pounds). Fifteen vehicles would fit in a 8ft X 8ft X 20ft container.

Launch: Launch is assisted by rocket booster

Recovery: Not required since its mission requires that the vehicle be expendable. However, a recovery parachute could be incorporated at the expense of fuel or payload.

(4:20-26)

Name of RPV: Brave 3000

Manufacturer: Boeing Military Airplane Company

Cost: Unknown

Mission: Suppression/destruction of radar-guided air defense systems, reconnaissance, target acquisition, jamming, electronic counter measures, decoy, and air attack. This vehicle can be preprogrammed to attack a target with a warhead capacity of 150 pounds and a 35 pound seeker

Sensors: Camera and infrared sensors; the system has the capacity to carry a 131.5kg fuel/payload combination

Range: 496km (267.9NM)

Ceiling: 7600 meters (25,000 feet)

Maximum speed: 378 kts (700km per hour)

Endurance: 1 hour

Communications: Unknown

Navigation system: Preprogrammed

Survivability: Expendable

Size: Length - 4 meters (13 feet); wing span - 2.13 meters (7 feet)

Lanuch: Surface or air launched

Recovery: Not required

(4:20-26; 20:64-75; 21:109-120)

Name of RPV: CH-84 Pegasus

Manufacturer: Aerodyne Systems Engineering Limited

Cost: Unknown

Mission: This vehicle has the ability to operate from destroyer-sized ships in weather conditions up to sea state 5

Sensors: TV, FLIR, laser rangefinder/designator and others

Range: Unknown

Ceiling: 3,350 meters (11,000 feet)

Maximum speed: 150kts

Endurance: 6.5 hours at 55kts; payload - 455kgs (1,000 pounds)

Communications: Two way data link

Navigation system: Radio controlled

Survivability: Unknown

Size: Rotor diameter - 20 feet; height - 9.0 feet; total weight - 2,600 pounds, empty weight - 745 pounds; payload/fuel weight - 1,855 pounds

Launch: Conventional helicopter take off; vehicle cannot be air launched

Recovery: Same as helicopter

(3:108)

Name of RPV: CL - 227, Sentinal

Manufacturer: Canadair

Cost: Unknown

Mission: This vehicle can hover at speeds of as slow as five knots, and search, detect, and designate targets.

Sensor: FLIR, TV, laser rangefinder/designator

Range: 30NM

Ceiling: 3,050 meters (10,000 feet)

Maximum speed: 80kts

Endurance: 3-4 hours with a 27-46kg (60-100 pound) payload

Communications: Secure data link

Navigation system: Unknown

Survivability: The vehicles infrared signature is 0.05 Watts per steridian, its radar cross section is 0.1 square meters for the body and 0.01 square meters for the rotor blades. The vehicle consists of a Kevlar/metal structure with a radar absorbant coating, and the rotor blades are made of low reflecting composites and radar absorbing material. The low rotor-tip speeds result in a low acoustic signature.

Size: Rotor diameter - 2.52 meters (8.25 feet); height - 1.63 meters (5.33 feet)

Launch: Conventional helicopter launch

Recovery: Conventional helicopter recovery

(24:66-70; 53:35-39; 60:103-105)

Name of RPV: CL - 289

Manufacturer: Canadair/Dornier

Cost: Unknown

Mission: Electronics reconniassance and other reconniassance. Dornier estimates that 200 vehicles will provide the reconnaissance value of 60 RF-4E Wild Weisel aircraft. The CL-289 will require one-half the number of support personnel and initial investment, and 20 percent of the operating cost of the equivalent RF-4Es. The 200 CL-289s can generate 150-200 sorties per day while the 60 RF-4Es will generate 60-100 sorties per day.

Sensors: Electronic counter measures sensors, infrared line scanner, and high resolution camera

Range: Unknown

Ceiling: Unknown

Maximum speed: Unknown

Endurance: Unknown

Communications: Unknown

Navigation system: The flight plan can be preprogrammed with ten turning points and standard patterns.

Survivability: Very small infrared, and visual signatures

Size: Length - 3.5 meters (4.9 feet); 0.38 meter

(1.25 feet) tubular fuselage

Launch: Take-off is assisted by drop-off booster rocket

Recovery: Can conduct automatic, covert landing or parachute landing

(40:51-56; 57:1771-1777)

Name of RPV: CM - 44

Manufacturer: California Microwave Incorporated

Cost: Unknown

Mission: Manned or unmanned reconnaissance

Sensors: Various

Range: 3703km (2000NM)

Ceiling: Unknown

Maximum speed: 210kts

Endurance: 18 hours with a 400-600 pound payload

Communications: Unknown

Navigation system: Unknown

Survivability: Unknown

Size: Length - 5.64 meters (18.5 feet);

wing span - 8.84 meters (29 feet)

Launch: Conventional small aircraft take off

Recovery: Conventional small aircraft landing

(52:128 +)

Name of RPV: Design 754

Manufacturer: Grumman Corporation

Cost: Airframe only - $1,700,000;

payload cost - $3,000,000 - $5,000,000

Mission: Supplement or replace E-2C for airborne early warning; search localize, target and carry offensive munitions in AAW, ASUW, and ASW roles; and perform support missions in strike warfare, logistics, intelligence collection, and command and control roles.

Sensors: Various

Range: Unknown

Ceiling: 37,000 feet

Maximum speed: Unknown, cruise speed is 210kts

Endurance: 14 hours with 1,500 pound payload

Communications: Unknown

Navigation system: Unknown

Survivability: Unknown

Size: Wing span - 51 feet, wings fold parallel to fuselage; total weight - 4,455kgs (9,800 pounds)

Launch: Capable of taking off from DD 963 Spruence class destroyers, and FFG Perry class guided missile frigates in weather up to sea state seven.

Recovery: Same capabilities as those listed under launch.

(33:117-120)

Name of RPV: Heron 26

Manufacturer: Pacific Aerosystems Incorporated

Cost: Unknown

Mission: Reconnaissance, communications and radar jamming, communications relay, and electronic and communications intelligence gathering

Sensors: Day/night TV, FLIR or infrared line scanner, panoramic camera, or other payloads for communications relay, jamming, or electronic intelligence gathering

Range: 170NM

Ceiling: Standard configuration - 11,500 feet; high-altitude configuration - 20,000 feet

Maximum speed: 105kts, economy cruise - 85kts

Endurance: 5 hours with a 34kg (75 pound payload), or 10 hours with a 11.3kg (25 pound) payload

Communications: Unknown

Navigation system: Omega or Navstar systems, preprogrammed missions with 99 way points defined by altitude, latitude, longitude, and airspeed

Survivability: Constructed almost completely of carbon/graphite, and has a radar cross section of 0.1 square meters

Size: Length - 3.93 meters (12.9 feet);

height - 1.16 meters (3.8 feet) wing span for standard configuration - 4 meters (13.1 feet), for the high altitude configuration - 6.31 meters (20.7 feet)

Launch: Autonomous operation and automatic recovery is available. Vehicle take-off is assisted by a fall-away booster rocket

Recovery: Via parachute or extendable fuselage skid

(45:63-66)

Name of RPV: Mastiff MK III

Manufacturer: Tadiran

Cost: Unknown

Mission: Reconnaissance, artillery forward observer, and laser designator

Sensor: Optical systems

Range: 73NM

Ceiling: 14,700 feet

Maximum speed: 100kts

Endurance: 6 hours with a payload of 30kgs (70.4 pounds)

Communications: Unknown

Navigation system: Flight profile is controlled from the ground station

Survivability: Proven by Israeli Armed Forces

Size: Length - 3.3 meters (10.8 feet); wing span - 4.2 meters; height - 0.8 meters (2.63 feet); total weight - 115kgs (253 pounds)

Launch: Conventional airplane take-off

Recovery: Conventional airplane recovery

(27:74-76)

Name of RPV: Mirach 20, Pelican

Manufacturer: Meteor Costruzioni Aeronauticheed
Elettroniche S.P.A.

Cost: Unknown

Mission: Search and detection of ship targets; perform decoy or electronic warfare missions

Sensors: Acquisition radar and infrared sensor/FLIR which can detect ship targets at ranges of 43nm (80,000 meters) from an altitude of 3,300 feet (1,000 meters)

Range: Unknown

Ceiling: 11,485 feet

Maximum speed: 108kts

Endurance: 4 hours with 25kg (55 pound) payload

Communications: Unknown

Navigation system: Navstar, satellite navigation

Survivability: Unknown

Size: Length - 3.6 meters (11.9 feet);
wing span - 3.8 meters (12.5 feet)

Launch: Take-off is assisted by jettisonable rocket booster

Recovery: Parachute or skid recovery

(4:20-26; 62:385-390)

Name of RPV: Mirach 70

Manufacturer: Meteor

Maximum speed: 194kts

Endurance: 1 hour with 20kg (44 pound) payload

Size: Length - 3.66 meters (12 feet); wing span - 3.57 (11.7 feet); total weight - 260kgs (572 pounds)

All other data is the same as for the Mirach 20.

Name of RPV: Mirach 100

Manufacturer: Meteor

Cost: Unknown

Mission: Reconnaissance

Sensors: Low-light-level TV plus camera, and infrared line scanner, or electronic warfare reconnaissance payloads

Range: 155NM

Ceiling: Unknown

Maximum speed: 450kts

Endurance: 1 hour with 40kg (88 pound) payload

Communications: Real-time secure data link

Navigation system: Preprogrammed flight profile

Survivability: Unknown

Size: Length - 3.9 meters (12.8 feet); wing span - 1.8 meters (5.9 feet); total weight - 310kg (682 pound)

Launch: Rocket booster assisted ground launch, or air launch

Recovery: Parachute

(62:385-390)

Name of RPV: Mirach 600

Manufacturer: Meteor

Cost: Unknown, this platform is in early developmental stage

Mission: Air-to-air interceptor, close air support, and strike warfare

Endurance: 2 hours with 300-500kg (661-1,102 pound) payload

Size: Length - 6.1 meters (20 feet); wing span - 3.6 meters (11.8 feet)

(6:385-390)

Name of RPV: Merlin 200 RPL

Manufacturer: ASVEC Limited

Cost: Unknown

Mission: Reconnaissance

Sensors: Infrared line scanner, or 35MM camera

Range: Standard configuration - 250km (155NM); extended range configuration 500km (310NM)

Ceiling: 15,000 feet

Maximum speed: 175kts

Endurance: Standard configuration - 2 hours; extended range configuration - 4 hours; both with a 20kg (44 pound) payload

Communications: Real-time data link

Navigation system: Unknown

Survivability: Constructed of double skinned, honeycomb core which is reinforced with glass fiber

Size: Length - 3.04 meters (9.97 feet); wing span - 3.45 meters (11.32 feet)

Launch: Catapult rail launch

Recovery: On skids or via a parachute

Name of RPV: NV-144R

Manufacturer: Northrop Corporation

Cost: Unknown

Mission: Antiair warfare, decoy, jamming, reconnaissance and target designation; it is equipped with identification- friend-or-foe (IFF) transponder, and it can perform air-to-air dog fights while performing high-g turns. It can also carry the ALE-44 pod for dispensing chaff, and flares.

Sensors: FLIR, cameras, jammers, target designators, and electronic warfare sensors

Range: 960NM

Ceiling: 50,000ft

Maximum speed: 580kts

Endurance: 2.5 hours with a 136.4kg (300 pound) payload

Communications: Unknown

Navigation system: Navstar GPS, it can operate under radio control or fly preprogrammed profile which can be updated in flight.

Survivability: Unknown

Size: Length - 5.94 meters (19.5 feet); wing span - 3.11 meters (10.2 feet); diameter - 0.51 meters (20 inches)

Launch: Unknown

Recovery: In water or overland recovery via a parachute (56:326-327)

Name of RPV: Phoenix

Manufacturer: Flight Refueling Limited

Cost: Unknown

Mission: Defense suppression, jamming, electronic warfare intelligence interception, reconnaissance, and target designation

Sensors: Infrared imaging camera with 2.5x10 telescopic lens, infrared line scanner, electronic warfare modules, target designation systems

Range: Unknown

Ceiling: Unknown

Maximum speed: Unknown

Endurance: 4 hours

Communications: Rela-time data link

Navigation System: Unknown

Survivability: Composed mostly of composite materials, and therefore has reduced radar reflectivity

Size: Unknown

Launch: Pneumatic

Recovery: Parachute

(12:91-97)

Name of RPV: Pioneer

Manufacturer: AAI Corporation

Cost: U.S. Navy entered first contract for three systems (21 vehicles) for $25,800,000 in 1986

Mission: Day/night reconnaissance, and naval gunfire adjustments

Sensors: FLIR or TV

Range: 100NM mission radius

Ceiling: 15,000 feet

Maximum speed: 100kts, 50-80kts cruise

Endurance: 5 hours with a 100 pound payload

Communications: Secure two-way data link

Navigation systems: Radio controlled autopilot

Survivability: The airframe is fabricated of composite materials, and therefore, it has a reduced radar signature. Size: Length - 4.9 meters (16 feet); total weight - 400 pounds

Launch: Catapult rail launched, conventional wheeled take-off, or rocket assisted take-off

Recovery: Conventional wheeled landing, cable arrested landing, or net recovery

(24:66-70)

Name of RPV: Raven I

Manufacturer: Flight Refueling Limited

Cost: Unknown

Mission: Radar or communications jamming, or reconnaissance

Sensors: TV, daylight still photography, or electronic payloads for communications or radar jamming

Range: 43NM

Ceiling: 8,000 feet

Maximum speed: 88kts

Endurance: 100 minutes with a 4kg (8.8 pound) payload

Communications: Real-time data link

Navigation system: Unknown

Survivability: Unknown

Size: Length 2.1 meters (6.9 feet);

Wing span - 2.7 meters (8.86 feet)

Launch: Unknown

Recovery: Unknown

(12:91-97; 20:64-75)

Name of RPV: Scout

Manufacturer: Israel Aircraft Industries

Cost: Unknown

Mission: Reconnaissance, target laser designation

Sensors: TV or infrared sensor

Range: 54NM, the range can be doubled if control of the RPV is passed to another ground station

Ceiling: Unknown

Maximum speed: 95kts

Endurance: 7 hours

Communications: Real-time data link

Navigation systems: Preprogrammed or ground controlled

Survivability: Good, proven in service with Israeli Armed Forces

Size: Length - 3.7 meters (12.14 feet); wing span - 3.6 meters (11.8 feet); height - 0.9 meters (2.95 feet); total weight - 145kgs (319 pounds)

Launch: Standard airplane take-off

Recovery: Standard airplane recovery

(27:74-76)

Name of RPV: R4E-40 Skyeye

Manufacturer: Lear Sigler

Cost: Unknown

Mission: Reconnaissance

Sensors: FLIR and infrared line scanner simultaneously, daylight TV, 35mm camera, or meteorological package

Range: Unknown; the typical command and control range is 80NM.

Ceiling: 18,000 feet

Maximum speed: 130kts; cruise - 70kts

Endurance: 8 hours with a 63.64kg (140 pound) payload
3 hours with 55kg (120 pound) payload on the wings and 18.18kg (40 pound) payload in the nose

Communications: Frequency-modulated data link

Navigation systems: Omega or Navstar with 256 preprogrammed way points that can be reprogrammed in flight.

Survivability: Fuselage is made mostly of Kevlar, glass fiber and graphite composites which are covered with over eight pounds of radar absorbing material which reduces radar reflections from the internal equipment. The vehicles radar cross section is less than 0.15 square meters, and the infrared signature is 0.5 Watts per steridian.

Size: Length - 4.2 meters (13.8 feet); wing span - 5.33 meters (17.5 feet); total weight - 236.36kgs (520 pounds)

Launch: Catapult rail launched

Recovery: Primary - belly skid; backup - parachute or parafoil

(16:68-83; 24:66-70)

Name of RPV: Sprite

Manufacturer: M. L. Aviation Company Limited

Cost: Unknown

Mission: Reconnaissance

Sensors: Stabilized TV camera with zoom lens, or low-light-level TV, infrared imager, laser designator, chemical sensors, electronic intelligence sensor payloads

Range: Typical mission radius is 17NM

Ceiling: 9,000 feet

Maximum speed: 62kts

Endurance: 2.5 hours with a 6kg (13.2 pound) payload

Communications: Real-time data link

Navigation system: It can be preprogrammed for autonomous operations and recovery, or it can operate under the continious control of the ground station.

Survivability: Rotor blades are non-metallic to reduce its radar signature.

Size: Rotor diameter - 1.6 meters (5.25 feet)

Launch: Conventional helicopter launch

Recovery: Conventional helicopter recovery

(12:91-97; 53:35-39)

Name of RPV: Sparrowhawk (AEL 4800)

Manufacturer: AEL Limited

Cost: Unknown

Mission: Reconnaissance

Sensors: TV camera, infrared or thermal image enhancer

Range: 30km (16.2NM)

Ceiling: Unknown

Maximum speed: 162kts

Endurance: 90 minutes with 20kg (44 pound) payload

Communications: Real-time data link

Navigation system: Radio controlled

Survivability: Unknown

Size: Length - 2.77 meters (9.09 feet);

Wing span - 3.21 meters (10.53 feet); total weight - 60kgs (132 pounds)

Launch: Catapault launched

Recovery: Landing on belly or via parachute

(20:64-75)

APPENDIX II

HISTORY

The airplane that the Wright brothers brought to the Army in 1903 was a rather flimsy contraption. After looking it over, General Ferdinand Foch, who later became the Supreme Commander of the Allied Forces in France, dismissed it out of hand by stating: "That's good sport, but for the Army it is of no value." (26:47) Foch was a thoughtful student of warfare whose writings were widely used in war colleges of the time. His spurning of the airplane was, however, a classic example of throwing out the baby with the bathwater. To be sure, the Wright Brothers' aircraft was just a flimsy box kite with only the slenderest margin of weight-lifting capacity.

The airplane was eventually adapted by the U.S. Army Signal Corps in 1903. Although it may have seemed logical at the time, the decision to assign the airplane to the Signal Corps was to have profound consequences. Airplanes would be employed as the eyes of the Army rather than as offensive weapons geared to a strategic mission which would impact on the then entrenched horse borne cavalry doctrine. As a consequence of this organizational, or institutional sponsorship, at the close of World War I, the case for the airplane as a weapon of strategic potential had not been adequately demonstrated to those in command of the Army. (28:6). If military intellectuals of the era, such as Foch, failed to perceive the potential powers of the airplane, it is easy to understand why the United States military has had some difficulty in soundly conceptualizing the potential of the pilotless aircraft.

This appendix will trace the beginnings of RPVs starting with the Kettering Bug and conclude with a present-day version of the RPV. There were numerous and varying aerospace reference sources addressed during this research. The terms RPV, drone and guided missile were contained in much of this literature and in some cases the meanings were used interchangeably.

The very first efforts to use the RPV concept originated around the start of World War I. These vehicles were called "Aerial Torpedoes," and this label, for vehicles containing explosives, remained in use until the early years of World War II when the term "power driven controllable bomb" was agreed upon. (15:Doc. 1) The first unmanned aerial targets were called just that "Aerial Targets." These aerial targets along with standard aircraft that were converted to remote controlled operation became known as "Drones." In the late 1940s and early 1950s, several unmanned weapons systems with wings and air breathing or rocket engines were developed. The popular term "Pilotless

Aircraft" was applied to them and they were further described as pilotless bombers (Matador and Shark) and pilotless interceptors (Bomarc). (8:11)

Elmer A. Sperry and Charles F. Kettering probably deserve credit for the first practical ideas and applications of remote control of aerial vehicles. Mr. Sperry of Sperry Gyroscope Company was encouraged by Peter Cooper Hewitt of the Naval Consulting Board to start work on controlling unmanned aircraft. In late 1915 or early 1916, a Sperry modified seaplane was demonstrated to the U.S. Navy. A report of the demonstration stated:

> The plane takes off the water under its own control, reaches a set height, takes and maintains a satisfactory compass course and after travelling a predetermined distance, dives downward and would have crashed in accordance with its design but for Sperry taking over hand control.

On 14 April 1917, the Navy recommended further development efforts on aerial torpedoes. (19:1; 8:13).

At about the same time that Sperry was starting his experiments on the aerial torpedo, Mr. Charles F. Kettering, president and general manager of General Motors Research Corporation, was working with the Army on a similar aerial torpedo, later called the Kettering Bug. Shortly after America's entry into World War I, the Signal Corps appointed a committee to look at the possibility of developing the aerial torpedo. Kettering submitted a minority report and on the strength of that report, he was authorized by the Signal Corps to proceed with development. (9:106) Kettering s idea called for a small pilotless/expendable bombing aircraft which was capable of carrying 200 pounds of explosives for fifty miles under its own power, and capable of hitting a given target with reasonable accuracy. The resultant 550 pound, 38 horsepower engine driven aerial torpedo with barometric/ gyroscopic altitude/heading references and pneumatically driven flight controls was successfully flown in October 1918. (19:4; 8:14)

While Sperry and Kettering worked on their aerial torpedoes, other projects which used vehicles with preset controls, and others with radio controls were in progress. In November 1917, the Navy demonstrated a robot N-9 bomber. Then on 6 March 1918, an unmanned flying-bomb type airplane was launched on the Sperry Flying Field. By September of that year, the Navy had progressed to the point where it was able to demonstrate the use of a JN-4 aircraft which was under the radio control from another airborne JN-4. (2:23-25; 8:15)

During the 1920-1929 decade, both the Army and the Navy converted existing airplanes into aerial torpedoes. Because of inherent aircraft instabilities and problems associated with presetting aircraft controls which can not compensate for changing environmental conditions, radio control was seen as the only viable way to go. (13:Doc. 1) No documentation of any significant advances in RPVs which might have been achieved during the 1930s was found. The absence of RPV advances was probably due to low military funding.

In September of 1939, Kettering wrote Hap Arnold, a Major General and Chief of the Army Air Corps, and told him that General Motors had made technical advances on the idea of the Kittering Bug torpedo. Funds for the Kettering Bug were authorized, its name was changed to Controllable Bomb, Power Driven, and tests of various launch and control techniques, which even included the use of television, were conducted. But, in late 1943, it was decided that the single 500 pound explosive payload was not adequate for the proposed mission. That meant that vehicles with a greater payload capacity were required . This requirement translated to vehicles with two engines, and meant that the new vehicle would have be designed from scratch. The project was, because of its history of slow progress, cancelled in favor of other developments. (13: Summary; 8:16)

One of these other developments was a series of power driven controllable bombs developed by the Army in the early 1940s. These developments produced three single production models (XBQ-1, XBQ-2A, and XBQ-3) which were twin engine, ground launched, controllable bombs capable of carrying 2,000 to 4,000 pounds of bombs to a distance of about 1,500 miles. (18: Doc.1)

During this same period, the Navy designed an assault drone built of plywood and designated the TDN. Contracts were made with the Interstate Aircraft and Engineering Corporation to build some of these bomb carriers (to be called TDRs) and to improve the design for other models. The Navy cooperated with the Army by having Interstate build some modified versions of this vehicle for the Army to evaluate. The XBQ-4(Navy TDR-1), XBQ-5(Navy TD2R-1), and XBQ-6(Navy TD3R-1) resulted from this interservice effort. The Navy expended 45 TDR-1s at Bougainville and Rabaul in September and October of 1944. (18:Doc.1; 8:18)

While these BQ series controllable bombs were being developed, modified PQ series target drones were being flown to demonstrate their utility, and to convince leaders that more funds should be allocated to this area. On 10 October 1943, two demonstrations were flown at Muroc, California. PQ-12As, modified with a television camera installed on one of the wings, and explosives in the fuselage, flew two successful demonstrations. One was an air-to-air demonstration which pitted one drone against another drone, and the second was an air-to-ground demonstration with a drone delivering explosives on a 30 foot by 30 foot target.

The remote control of all three aircraft used in this demonstration was accomplished from other airborne aircraft located a mile or more from the action. These development programs lost support about the middle of 1944 because it was believed that the development of these aircraft required almost as much effort and resources as that required to develop manned combat airplanes. (18:Doc.1; 8:18)

The glide bomb program started in early 1941 and was a part of the unpowered controllable bomb efforts. The period of 1941 through 1945 produced a family of glide bombs (GB) from GB-1 to GB-15. The GB-1 was essentially a standard 2,000 pound bomb with a set of wings, a twin tail afterbody and a preset control assembly. The GB weapons all used the same basic airframe, but with different guidance systems in the nose. The GB-4 had a television camera in the nose, while the GB-7 had a radar seeker. (14:Summary) The GB-1 simply glided into the target while later models like the GB-4 had radio control. Several of the glide bombs did receive combat tests during World War II but for the most part were refined too late in the war for general combat use. A Navy glide bomb, the BAT, which was very similar to the Army's GB-7B, was used against Japanese shipping in the Pacific in the later stages of the war. (50:88-89) Although the GB series was too late for much use in World War II, they introduced concepts such as standoff bombing, and remote television and radar guidance, all of which are concepts in different stages of evaluation today. (8:20)

Probably one of the most interesting and best known ideas associated with RPVs to come out of World War II was Project Aphrodite. Aphrodite took war weary B-17s stripped them and added a radio control system. This simple system required that a pilot take off in the B-17, clean up the take-off configuration and set the aircraft on course. After turning radio control over to the mother ship, the pilot would bail out. The Air Instrumentation and Test Requirement Unit was activated at Clovis, New Mexico, on 1 February 1946. The unit deployed to Eniwetok and on Able Day, 1 July 1946, four drone planes guided by a mother aircraft, flew through the contaminated cloud of the nuclear explosion and all returned safely to Eniwetok. (5:1; 8:23)

Unlike the World War II period, the Korean War period did not bring large gains in drone development. In fact, very little progress was recorded. This may have been because of the nature of the air war, and the sanctuary policy of the United States. During the Korean War, development did continue on the jet powered vehicle designated the Q-2. The Q-2 was capable of flying at 521 knots at 15,000 feet, and had a service ceiling of 40,000 feet. In the spring of 1953, a production run was made for the Army. This vehicle was procured by all three services and was labeled the Q-2A by the USAF, XM-21 by the Army and KDA-1 by the Navy. A major redesign provided greater payload capability, and the new vehicle, designated Q-2C, was first flown in 1950 and went into production in January of 1960. (31:527; 8:25)

The 1960 U-2 incident, where Francis Gary Powers was shot down over the U.S.S.R., and the Cuban missile crisis in the Fall of 1962 gave impetus to finding low-risk means of acquiring timely photographic intelligence. The Air Force Logistics Command took the Q-2C, now called the BQM-34, and began 10 years of modifications whose goal was to provide a reconnaissance capability along with improved vehicle performance.

Many of the models produced for use in South East Asia (SEA) had specialized capabilities which were designed to meet the requirements of a specific situation. From the introduction of the basic target vehicle in 1958 to late 1971, these aircraft flew over "... 17,500 flights in every conceivable climatic and combat environment." (55:21)

In the combat environment of SEA the modified AQM-34 was used in a reconnaissance role. Although most of the material remains classified, the unclassified data indicates that various versions were used for both high and low altitude photographic, and electronic reconnaissance missions. The idea of using a remotely piloted vehicle in a high threat area to acquire vital intelligence was proven as a feasible concept. (8:27)

Due to the draw-down of all military activities (especially those needing any form of additional funding) following the Vietnam War, the expansion of interest and development in RPVs did not occur in the mid-to-late 1970s.

The successful 1982 Israeli attack on Syrian antiaircraft sites in the Bekaa Valley proved the capabilities of a new generation of RPVs. These RPVs using acquired U.S. technology, have had a significant impact in increasing the interest in military applications for these vehicles. The sensors available for these vehicles, because of recent advances in miniaturization, and other technological improvements make the RPV highly attractive.

With this as background, it was not until 1983 that new interest was generated within the U.S. Navy. "Secretary of the Navy John Lehman, the Chief of Naval Operations and several other high-ranking officers were made aware of how the Israeli government used the RPV and realized its potential." In July 1985 Naval Air Systems Command was directed to implement a program using off-the-shelf technology that would enable an RPV unit to be deployed to the fleet, as soon as possible. (46:15)

In April 1986, installation of an RPV system, including the internal and external control stations, began aboard USS

Iowa (BB-61). A rocket-assisted take-off capability was introduced as the battleship's answer to catapults and a net was designed for shipboard recoveries. The system has demonstrated its capability to support gunfire spotting during the battleship's work-ups. USS Iowa deployed to the Mediterranean in September 1987 with an operational RPV system on board. (46:16)

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